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ABSTRACT TITLE: Complete Modeling of Rotary Ultrasonic Motors Actuated By Traveling Flexural Waves

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ABSTRACT TEXT

Efficient miniature actuators that are compact and consume low power are needed to drive space and planetary mechanisms in future NASA missions. Ultrasonic rotary motors have the potential to meet this NASA need and they are developed as actuators for miniature telerobotic applications. These motors have emerged in commercial products but they need to be adapted for operation at the harsh space environments that include cryogenic temperatures and vacuum and also require effective analytical tools for the design of efficient motors. A hybrid analytical model was developed to address a complete ultrasonic motor as a system. Included in this model is the influence of the rotor dynamics, which was determined experimentally to be important to the motor performance. The analysis employs a 3D finite element model to express the dynamic characteristics of the stator with piezoelectric elements and the rotor. The details of the stator including the teeth, piezoelectric ceramic, geometry, bonding layer, etc. are included to support practical USM designs. A brush model is used for the interface layer and Coulomb's law for the friction between the stator and the rotor. The theoretical predictions were corroborated experimentally for the motor. In parallel, efforts have been made to determine the thermal and vacuum performance of these motors. Experiments have shown that the motor can sustain at least 230 temperature cycles from 0°C to -90°C at 7 Torr pressure significant performance change. Also, in an earlier study the motor lasted over 334 hours at -150°C and vacuum. To explore telerobotic applications for USMs a robotic arm was constructed with such motors.

KEYWORDS: Piezoelectric Motors, Ultrasonic Motors (USMs), Stators and Rotors, Modal Analysis, Actuators, Active Materials

BRIEF BIOGRAPHY: Dr. Xiaoqi Bao is a Member of the Engineering Staff at the NDE and Advanced Actuators (NDEAA) team of the Jet Propulsion Laboratory. He joined JPL in May 1997 after serving for about ten years as a Research Associate at Pennsylvania State University. He received his Ph. D., Physics, in 1985 and M. Sc., Physics, in 1982 from the Chinese Academy of Sciences, Beijing, China. In 1986, Dr. Bao was a Visiting Scientist at the Dept. of Electrical Engineering of Toyama University, Japan. He has research experience in piezoelectric motors, SAW sensors, piezoelectric actuators, composite materials, active vibration and sound control, and intelligent materials/structures. He has published more than 30 papers in related research areas.